DOI: 10.7860/JCDR/2013/7376.3850

Original Article

Dentistry Section

Effect of Simulated Microwave Disinfection on the Mechanical Properties of Three Different Types of Denture Base Resins

JAGADISH KONCHADA[1], SUMA KARTHIGEYAN[2], SYED ASHARAF ALI[3], VENKATESHWARAN R[4], RAMESH AMIRISETTY[5], ANURAG DANI[6]

ABSTRACT

Statement of problem: Disinfection of prostheses with chemical solutions has deleterious effects on dentures. The appropriate power setting of microwave for disinfection, without affecting denture base properties, is a controversy.

Purpose: To evaluate and compare the effect of simulated microwave disinfection at a recommended power setting on the mechanical properties of three denture base heat polymerized acrylic resins.

Material and Methods: Ninety rectangular specimens of each acrylic resin of 65mm × 10mm × 3 mm dimensions were divided into three groups. Group A (Trevalon), Group B (Trevalon- HI), Group C (Ivocap). In each group, thirty specimens were divided into three subgroups with ten specimens in each and they were submitted to MicroVickers hardness, flexural strength, and impact strength tests. In each subgroup, five specimens were tested before the simulated microwave disinfection and they served as the control group. The remaining five were tested after simulated microwave disinfection and they were considered as the experimental group. Simulated microwave disinfection was done in a domestic microwave oven at 650 W for 5 minutes.

Results: The data were analyzed using One-way ANOVA and t-test. The mechanical properties of the three denture base resins were not altered after simulated microwave disinfection, as compared to those of the controls.

Conclusion: Microwave irradiation at 650 W for 5 min did not affect the mechanical properties of the three denture base resins. Domestic microwave oven, at the prescribed setting, can be used as an alternative method of disinfection for complete dentures without affecting their properties.

Keywords: Disinfection, Flexural strength, Impact strength, Hardness

INTRODUCTION

Prostheses which are contaminated with pathogenic microorganisms such as bacteria, fungi and viruses serve as a potential source of transmission of infection between patients and dental personnel [1]. Disinfection of these prostheses is necessary, to avoid cross contamination. Disinfection is the destruction of most but not necessarily all microorganisms [2].

Disinfection of prostheses with chemical solutions such as sodium hypochlorite, glutaraldehyde, and chlorine dioxide or alcoholic solutions has been recommended [3]. Immersion in chemical solutions may stain and whiten the plastic components of prostheses [4], due to the bleaching actions of the solutions on the denture base resin, corrosion of the frame work [5], or promotion of severe risk of cytotoxicity. To overcome this, microwave disinfection has been suggested as an alternative method for prosthesis disinfection. Webb et al., [6] reported that microwaving may be a method which is more effective for denture sterilization than denture soaking in sodium hypochlorite. Different time and power settings of microwave ovens have been proposed for denture disinfection. Though microwave disinfection at 604W for 10 min is bactericidal, an unacceptable dimensional stability has been observed in acrylic resin bases [7]. Overall, damage to denture base, surface roughness and poor adaptation were observed after a microwave disinfection at 690W for 6 minutes [8]. A microwave irradiation at 650W for 5 min promoted inactivation of *S.aureus*, *P.aeruginosa*, and spore forms of *B.subtilis* [5] and it is an effective method for acrylic resin disinfection. Though the bactericidal effect of microwave irradiation at 650W for 5 minutes has been proven, its effect on the mechanical properties of commonly used denture base acrylic resins, such as flexural strength, impact strength, hardness has not been tested.

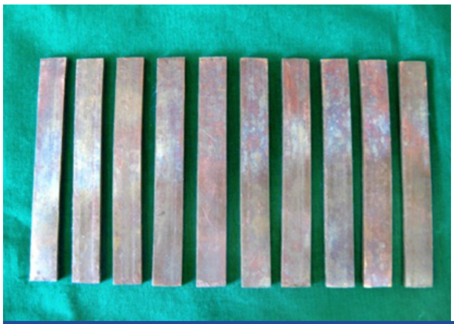
The purpose of this study was to evaluate the effect of simulated microwave disinfection at 650 W for 5 min on the hardness, impact strength, and flexural strength of three different types of denture base acrylic resins. The null hypothesis was that the simulated microwave disinfection did not affect the mechanical properties of the denture base acrylic resins at this recommended power setting.

MATERIAL AND METHODS

Ninety rectangular specimens of acrylic resins of 65mm X 10 mm x 3 mm dimensions (ISO Specification 1567) [9], were used in this study. These specimens were divided into three groups of 30 samples each. In group A, 30 specimens of conventional heat cure acrylic resin (Trevalon, Dentsply India Pvt Ltd), in group B, 30 specimens of High Impact acrylic resin (Trevalon- HI, Dentsply India Pvt Ltd) and in group C, 30 specimens of Injection moulded acrylic resin (Ivocap, Ivoclar Vivadent) were made. In each group, 30 specimens were divided into three subgroups and each was tested for Microvickers hardness, flexural strength and impact strength respectively. In each subgroup, 5 specimens were tested before simulated microwave disinfection was done and they served as the control group, and 5 specimens were tested after simulated microwave disinfection, which formed the experimental group.

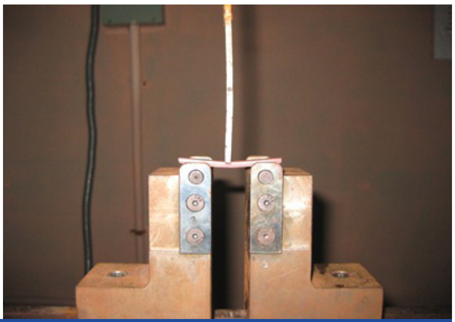
To fabricate the rectangular acrylic specimen, a metal Die (Steel) was prepared to simulate the bar specimen of dimension, 66mm x 10.5mm x 3.5 mm [Table/Fig-1]. This die was invested in a conventional brass flask (Varsity flask; Jabbar and company, India) by using a type III dental stone (Goldstone; Asian chemicals, India) and it was prepared at a ratio of 30 mL water to 100 g powder. After the stone was set, the dies were removed and a cold mould seal (DPI heat cure cold mould seal; Dental products of India) was applied to the stone mould surface. This was allowed to dry at room temperature before it was packed.

Acrylic resin was mixed according to the manufacturer's instructions (Trevalon: 24g powder to 10 mL liquid; Trevalon-HI:25g-11 mL), it was packed in the respective mould in the dough stage, processed in an acrylizer (C-73A;Confident dental equipments LTD, India) at 74°C for eight hours and terminally boiled for one hour [10]. Specimens were bench cooled overnight before they were deflasked. The polymerized resin samples were retrieved from the mould and the excess resin were trimmed from all specimens with a bur (Dental future systems; Germany). For injection moulded resin specimens, predosed resin in capsules was mixed in a patented Cap Vibrator – thus producing a fully homogenous mix of the materials. Injection of the Ivocap denture material into the flask was done under 6 bar pressure and it was maintained during the subsequent polymerization. The design of the flask plus the thermal insulator enabled controlled polymerization from bottom to top. Each specimen was trimmed and finished with stone and sand paper. Polishing was done using Pumice slurry with a white bristle brush and a cloth buff. After final polishing, the specimens presented dimensions of 65.0 x 10.0 x 3.0 mm according to ISO 1567 specifications. All the samples were stored in water at 37°C for 24 hours before they were tested.



[Table/Fig-1]: Metal Dies (Steel)

[Table/Fig-2]: Domestic Microwave Oven



[Table/Fig-3]: Three Point Bending Test

[Table/Fig-4]: Impact Testing Machine (Enkay Pr 09/E1/16)
[Table/Fig-5]: Micro Vickers Hardness Testing Machine

Each of the ten specimens in a sub-group was tested for MicroVickers hardness, flexural strength, and impact strength. In each subgroup, 5 specimens were immersed in 150 mL of distilled water in a glass container and they were placed in a domestic microwave oven (ONIDA power convection 21; Mirc electronics ltd; Mumbai) [Table/Fig-2] at 650 W for 5 min [5]. The remaining 5 specimens served as the controls. For flexural strength, the specimens were submitted to 3-point bending test [11], in a universal testing machine (FIE UTM) [Table/Fig-3]. Flexure value was obtained by using the equation:

F=3 WL/2bd2,

Where: F=flexure strength (KN /mm^2); W= ultimate load before the failure (KN); L= distance between the support points (50 mm); b= specimen width (10 mm); d= specimen thickness (3 mm). Results were obtained in MPa by multiplying the values in KN /mm^2 by the constant, 1000.

Impact strength of the acrylic resin was tested by using impact testing machine [Table/Fig-4] and the Charpy system, [11] (ENKAY enterprises, New Delhi). Impact strength values were obtained directly in the machine scale. Impact strength was expressed in gramforce-centimeters (gf-cms).

Micro Vickers hardness was tested in a micro hardness tester (Shimadzu HMV-2000; Shimadzu, Tokyo, Japan) [Table/Fig-5] and it was calibrated with load of 25 g for 10 sec. Three indentations were made on the surface of each specimen, one in the centre and one at each end. The average of the three indentations was considered as the specimen hardness and it was was expressed as KHN.

Data from the non-disinfected and simulated microwave disinfected specimens were analyzed by one-way ANOVA and t-test. (Significance level $p < 0.05$).

RESULTS

For flexural strength, there was no statistical difference ($p > 0.05$) between control group and experimental groups for Trevalon, Trevalon – HI, and Ivocap specimens [Table/Fig-6].

For Impact strength, there was no statistical difference ($p > 0.05$) between control group and experimental groups for Trevalon, Trevalon – HI and Ivocap specimens [Table/Fig-7].

For Micro Vickers Hardness, there was no statistical difference ($p > 0.05$) between control group and experimental groups for Trevalon and Trevalon– HI and Ivocap specimens [Table/Fig-8].

Materials	Control Group	Experimental Group	p–value
Trevalon	156.62 ± 18.07	151.70 ± 19.79	0.65
Trevalon – HI	132.14 ± 22.60	124.96 ± 13.17	0.20
Ivocap	90.06 ± 10.88	96.90 ± 16.04	0.16

[Table/Fig-6]: Comparison of Flexural Strength values between Control group and Experimental group (MPa) with their standard deviations

Materials	Control Group	Experimental Group	p–value
Trevalon	20394.92 ± 1.34	20394.32 ± 72.48	0.98
Trevalon – HI	20552.65 ± 86.83	20456.72 ± 42.22	0.78
Ivocap	20394.32 ± 0.00	20394.32 ± 0.00	0.07

[Table/Fig-7]: Comparison of Impact Strength values between Control group and Experimental group (gf-cm) with their standard deviations

Materials	Control Group	Experimental Group	p–value
Trevalon	16.18 ± 2.10	17.52 ± 2.00	0.31
Trevalon – HI	11.94 ± 1.18	13.74 ± 2.15	0.25
Ivocap	13.64 ± 1.86	14.96 ± 0.50	0.18

[Table/Fig-8]: Comparison of Micro Vickers Hardness values between Control group and Experimental group (KHN) with their standard deviations

DISCUSSION

In this study, three types of denture base resins i.e. Trevalon, Trevalon-HI, and Ivocap were subjected to simulated microwave disinfections and they were studied for their flexural strengths, impact strengths and hardness and the same were compared before simulated microwave disinfection.

The mechanical properties of any acrylic resin prosthesis should not be affected for reasonable microwave disinfection. The flexural strength, impact strength and hardness mechanical properties of the three denture base resins which were used in this study were not altered after simulated microwave disinfection. The null hypothesis in this study was accepted. Hence, microwave irradiation at 650W for 5 minutes should be a reliable method for disinfection of acrylic resin prosthesis when the mechanical stability is considered.

Flexural strength is a simultaneous measurement of tensile, compressive and shear bond strengths [12]. This flexural strength represents the loading that occurs on the denture in the mouth during the masticatory process. In the present study, flexural strength values which were analyzed under non-disinfection (control) and simulated microwave-disinfection (experimental) conditions [Table/Fig-6], for Trevalon, Trevalon – HI, and Ivocap denture base resins did not differ significantly from each other. Despite statistical similarity among the three acrylic resins, a decrease in flexural strength values for Trevalon and Trevalon-HI was observed in this current study. Probably, this may be due to uptake of water during microwaving and consequent resin plasticization, which may have made it more flexible and resilient [13]. However, Ivocap denture base showed increased flexural strength values, which could be related to a reduction in the residual monomer level, which may have been a result of the higher degree of conversion [14]. Impact strength is a measure of energy absorbed by the material when it suffers sudden fracture [12]. In this present study, the simulated microwave disinfection did not affect the impact strength values for Trevalon, Trevalon – HI and Ivocap denture base resins [Table/Fig-7]. It was assumed that the energy absorbed during the impact made by the tested materials was similar, probably because of the similar values of resilience, which may have produced statistically similar fracture strength values, even after simulated microwave disinfection [11]. Hardness test evaluates the material's ability to withstand possibility of abrasion over time, during denture use [12]. In this present study, Micro Vickers hardness for the three denture base resins was not affected by simulated microwave disinfection. An increase in hardness values which was observed in the present study, could be related to a reduction in the monomer level, as a result of further polymerization caused by the microwave irradiation. It is well-known that an increase in temperature of storage media results in higher material diffusion rates [15].

Nepelenbroek et al., [16] demonstrated that when acrylic resin specimens contaminated with individual suspensions of three bacteria (*P. aeruginosa*, *S. aureus*, *B. subtilis*) were sterilized by microwave irradiation (6 minutes/650 W) it was observed that microwaving for 6 minutes at 650 W produced deleterious effects on some physical and mechanical properties of acrylic resin specimens. Thus, reduced microwave exposure times should be chosen, to produce consistent disinfection without any adverse effects on acrylic resins. Carlos et al., [13] analyzed the effect of microwave post polymerization on the flexural strengths of four auto polymerizing reline resins and 1 heat-polymerized resin (Lucitone 550) and they found a flexure strengths which were more than those of other hard reline resins after microwave post polymerization at 550 W for 3 minutes. Maria Agnese et al., [8] evaluated the cumulative effect of two protocols of microwave disinfection (Protocol 1: 690 W/6 min; Protocol 2: 345 W/6 min) on surface roughness (Ra) and base plate adaptation of two denture resins and they proved that protocol 2 was safer than protocol 1 for both resins. These studies also proved that lower power settings did not affect the properties of denture base resins.

Dovigo et al., [5] evaluated the effectiveness of microwave irradiation at 650W for 5 min on disinfection of complete dentures contaminated with *S. aureus*, *P. aeruginosa* and *B. subtilis*. The power setting used in this study did not affect the mechanical properties of the three denture base resins.

The limitations of this study were, that it has utilized only a specific shape of specimens and that complex shapes like complete dentures were not used in this study. Further studies with such complex shapes are necessary to confirm the results of this study. Although attempts were made to characterize the effect of microwave irradiation on the mechanical properties, further research is necessary, to evaluate as to whether the effect of repeated microwave disinfection may be deleterious to these properties of the denture base acrylic resins.

CONCLUSION

Simulated microwave disinfection did not affect the flexural strength, impact strength and hardness of the three denture base resins which were used in this study. Microwave disinfection method can be effectively used in the elimination of microbial pathogens from prosthetic devices.

REFERENCES

[1] Kahn RC, Lancaster MV, Kate W. The microbiologic cross-contamination of dental prostheses. *J Prosthet Dent*. 1982; 47:556-59.
[2] Mariana Montenegro Silva, Carlos Eduardo Vergani, Eunice Teresinha Giampaolo, Karin Hermana Neppelenbroek, Denise Madalena Palomarispolidorio, Ana Lucia Machado. Effectiveness of microwave irradiation on the disinfection of complete dentures. *Int J Prosthodont.* 2006; 19:288-93.
[3] James J Lin, Stephen. M.Cameron, Dennis A Runyan, David W Craft. Disinfection of denture base acrylic resin. *J Prosthet Dent.* 1999; 81:202-26.
[4] Robert W.Rudd, E. Steve Senia, Ferne. K. Mc Cleskey, Ernest D. Adams. Sterilization of complete denture with sodium hypochlorite. *J Prosthet Dent.* 1984; 51:318-21.
[5] Livia Nordi Dovigo, Ana Claudia Pavarina, Daniela Garcia Ribeiro, Juliana Aparecida de Oliveira,Carlos Eduardo Vergani, Ana Lucia Machado. Microwave Disinfection of Complete Dentures Contaminated In Vitro with Selected Bacteria. *Journal of Prosthodontics.* 2009; 18:611–17.
[6] B.C.Webb, C.J.Thomas, D.W.S.Harty, M.D.P.Willcox. Effectiveness of two methods of denture sterilization. *Journal of Oral Rehabilitation.* 1998; 25:416-23.
[7] Sabrina Pavan, Joao Neudenir Arioli Filho, Paulo Henrique Dos Santos, Francisco de Assis Mollo. Effect of Microwave Treatments on Dimensional Accuracy of Maxillary Acrylic Resin Denture Base. *Braz Dent J.* 2005;16:119.
[8] Maria Agnese Pinto de Campos, Claudia Kochenborger, Diego Fabris Ferreira da Silva, Eduardo Rolim Teixeira, Rosemary Sadami Arai Shinkai. Effect of repeated microwave disinfection on surface roughness and baseplate adaptation of denture resins polymerized by different techniques. *Rev.Odonto Cienc*. 2009; 24:40-4.
[9] International organization for standardization. ISO 1567: dentistry: denture base polymers 1998; Geneve, Switzerland.
[10] Kenneth J.Anusavice. Denture Base Resins. In: Science of Dental Materials. 11th edn. St Louis: Elsevier Science; 2003.p. 733.
[11] Rafael Leonardo Xediek Consani, Erica Brenoe Vieira, Marcelo Ferraz Mesquita, Wilson Batista Mendes, Joao Neudenir Arioli-Filho. Effect of Microwave Disinfection on Physical and Mechanical Properties of Acrylic Resins. *Braz Dent J.* 2008; 19:348-53.
[12] Craig R, Craig RG, Power JM. Mechanical properties. In: *Restorative dental material*. 11th edn. Mosby; 2002. P. 68-124.
[13] Carlos Eduardo Vergani, Rosangela Seiko Seo, Ana Claudia Pavarina, Jose Mauricio dos Santos Nunes Reis. Flexural strength of auto polymerizing denture reline resins with microwave post polymerization treatment. *J Prosthet Dent*. 2005; 93:577-83.
[14] Blagojevic V, Murphy VM. Microwave polymerization of denture base materials. A comparative study. *Journal of Oral Rehabilitation.* 1999; 26: 804-8.
[15] Daniela Garcia Riberio, Ana Claudia Pavarina, Ana Lucia Machado, Eunice Teresinha Giampaolo, Carlos Eduardo vergani. Flexural strength and hardness of reline and denture base acrylic resins after different exposure times of microwave disinfection. *Quintessence Int.* 2008; 39:833-40.
[16] Karin Hermana Neppelenbroek, Ana Claudia Pavarina, Denise Madalena Palomari Spolidorio, Carlos Eduardo Vergani, Ewerton Garcia de Oliveira Mima, Ana Lucia Machado. Effectiveness of Microwave Sterilization on Three Hard Chair side Reline Resins. *Int J Prosthodont.* 2003; 16:616–20.

PARTICULARS OF CONTRIBUTORS:

1. Senior Lecturer, Department of Prosthodontics, Chhattisgarh Dental College & Research Institute, India.
2. Head of the Department, Department of Prosthodontics, Rajah Muthiah Dental College & Hospital, India.
3. Professor, Department of Prosthodontics, Rajah Muthiah Dental College & Hospital, India.
4. Senior Lecturer, Department of Prosthodontics, Sree Balaji Dental College, India.
5. Associate Professor,Department of Periodontics,Chhattisgarh Dental College & Research Institute, India.
6. Reader, Department of Prosthodontics,Chhattisgarh Dental College & Research Institute, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Dr. Jagadish Konchada,
Senior Lecturer, Department of Prosthodontics, Chhattisgarh Dental College & Research Institute
P.B.No.25, Sundra Rajnandgaon -491441, India.
Phone: 8602249900, E-mail: konchadaj@gmail.com

FINANCIAL OR OTHER COMPETING INTERESTS: None

Date of Submission: Aug 12, 2013
Date of Peer Review: Oct 03, 2013
Date of Acceptance: Oct 14, 2013
Date of Publishing: Dec 15, 2013